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Next Generation Collaborative Traffic Flow Management Systems

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Characteristics of Today's TFM (in the US)

- Distributed TFM architecture: Air Traffic Control System Command Center (ATCSCC) + Regional TFM units
- Monitoring system that provides traffic data to managers and users (ETMS)
- Major controls: ground holds, ground stops, ground delay programs (GDPs), Miles-in-Trail restrictions, strategic reroutes, tactical reroutes
- Recent trend toward collaborative decision making (CDM):
  - enhancement of ETMS data with user supplied data
  - greater user control over delay allocation
- Emerging Decision Support Tools

Today's TFM Challenges

- Coordination among ATCSCC, ARTCCs and users (including flight deck and AOCs)
- Improving data and prediction accuracy
- Development and delivery of effective decision support tools
- Lack of standardization of procedures and policies across regions
- Transfer of CDM technology to enroute airspace
- Better weather products and integration of weather products into decision support and control framework

Today → 2020: Trends That Impact TFM

- Structured traffic flows → unstructured traffic flows
- Centralized control and decision making → distributed control and collaborative decision making
- Enhanced, distributed communications and computing
- Increase in traffic

Background on Collaborative Decision Making (CDM)

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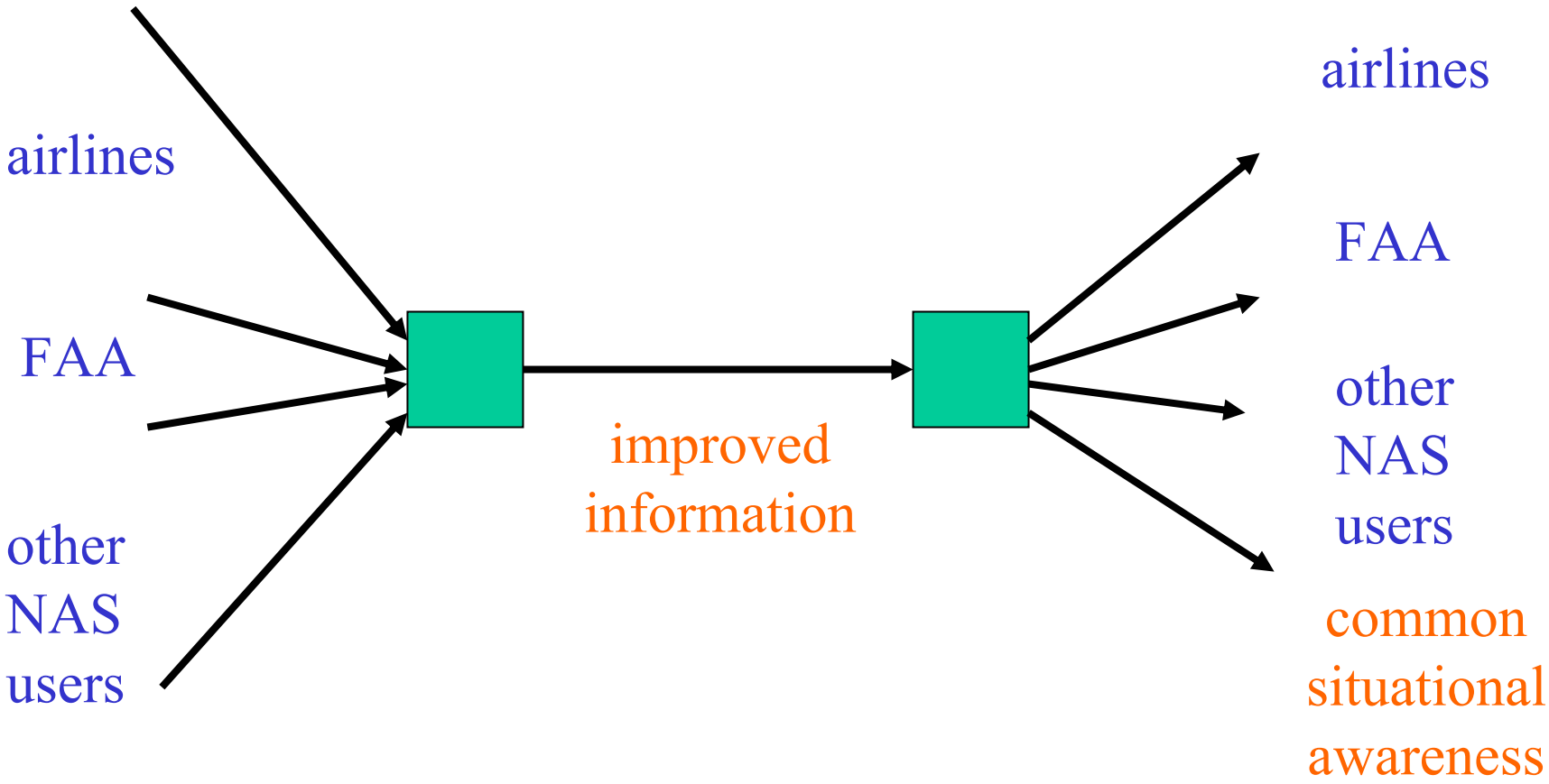
Fundamental Motivators for CDM in GDP Context:

- FAA (ATCSCC): desire for more up-to-date information on status of aircraft/flights to make better GDP decisions
- Airlines: desire for more control over allocation of delays to their flights

Solution:

- Communications network (CDM-Net) that allows real-time airline/FAA information exchange
- Resource allocation procedures (ration-by-schedule & compression) that give airlines more control *and encourage (or at least do not penalize) airline provision of up-to-date information*

Improved Information and Common Situational Awareness



Basic Resource/Slot Allocation Process

FAA: initial "fair" slot allocation

[Ration-by-schedule]

Airlines: flight-slot assignments/reassignments

[Cancellations and substitutions]

FAA: final allocation to maximize slot utilization

[Compression]

Revised View of GDP Processes

- Step 1: Fair allocation of landing time slots to airlines
- Step 2: Mediated, inter-airline bartering

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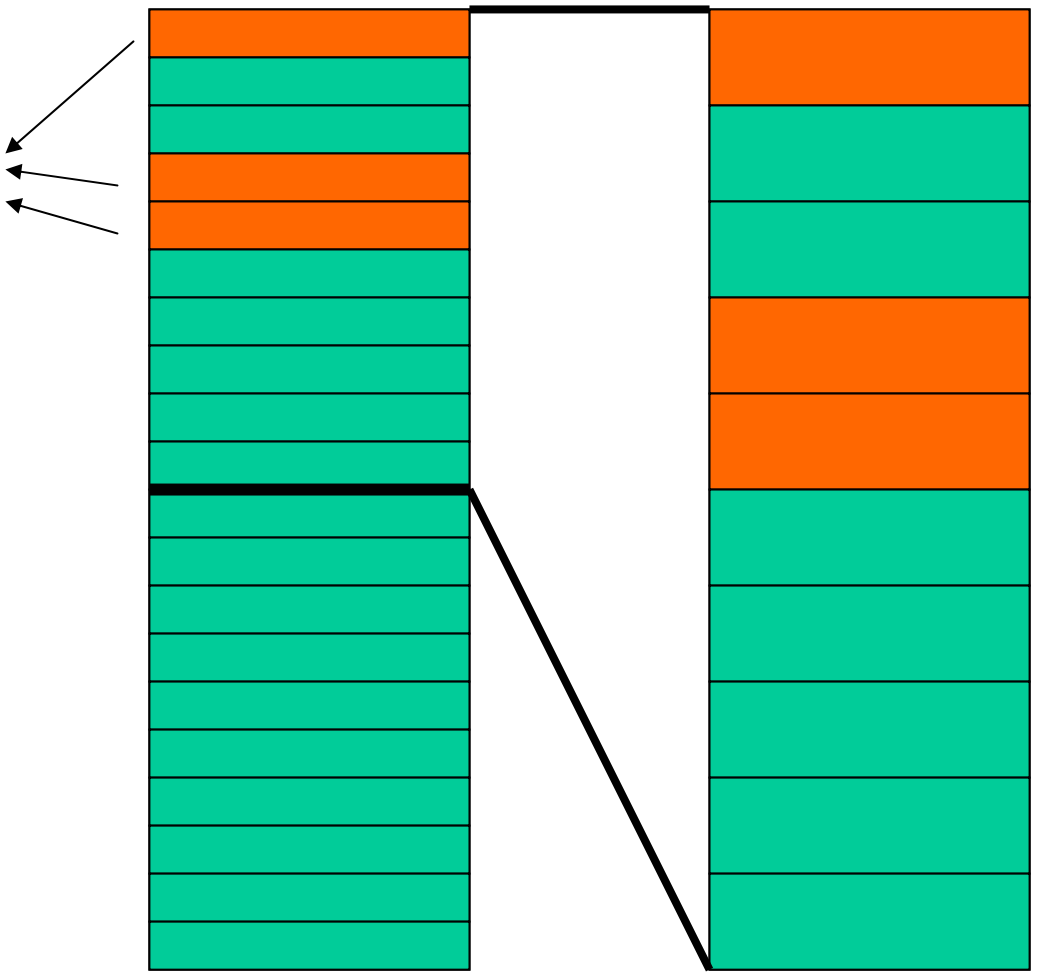
What is *Fair* Allocation??

OAG Schedule:
arrival rate = 60/hr

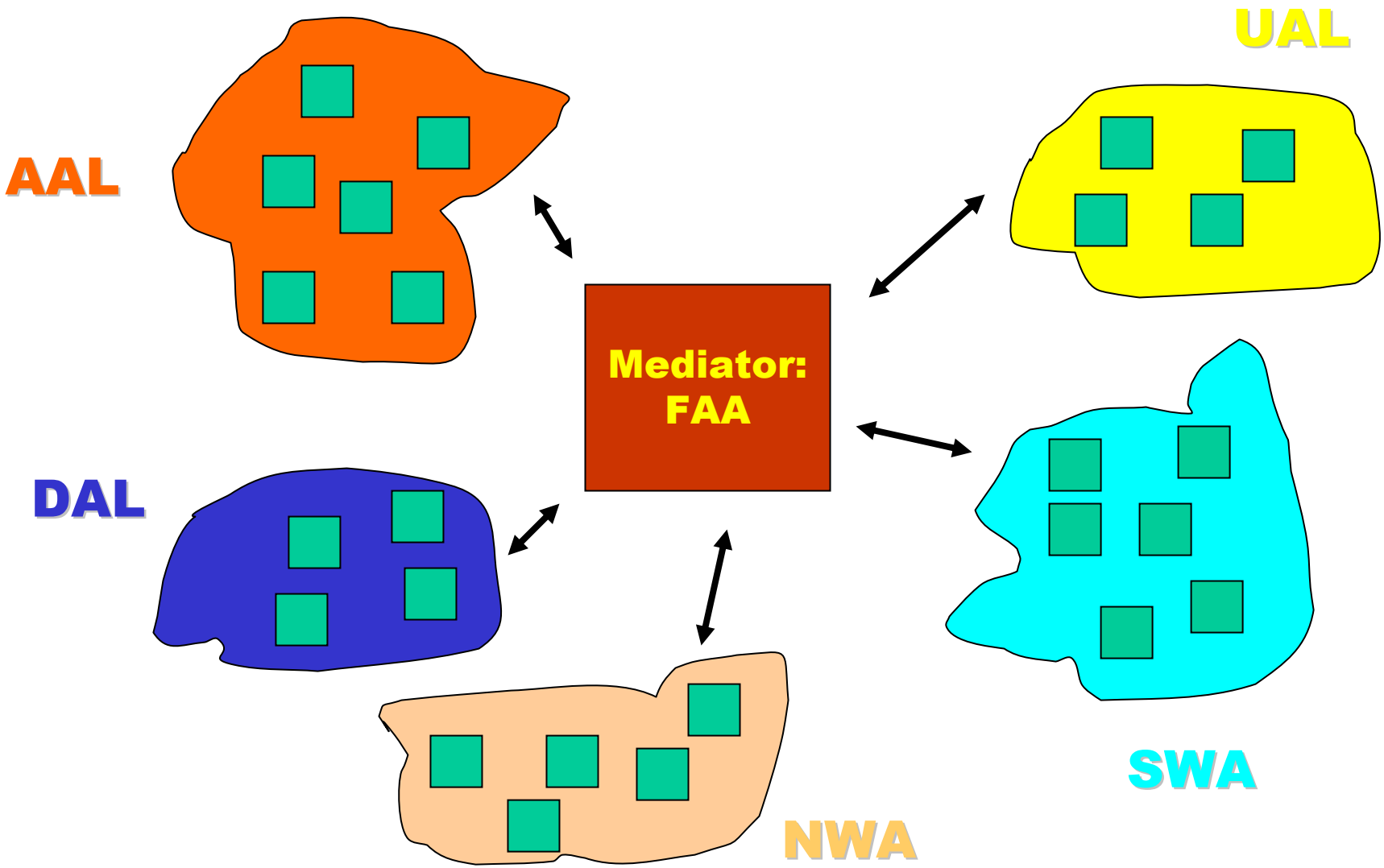
Degraded Conditions:
arrival rate = 30/hr



AAL has
3 slots in
1st 10 min

AAL has
3 slots in
1st 20 min

Inter-Airline Bartering

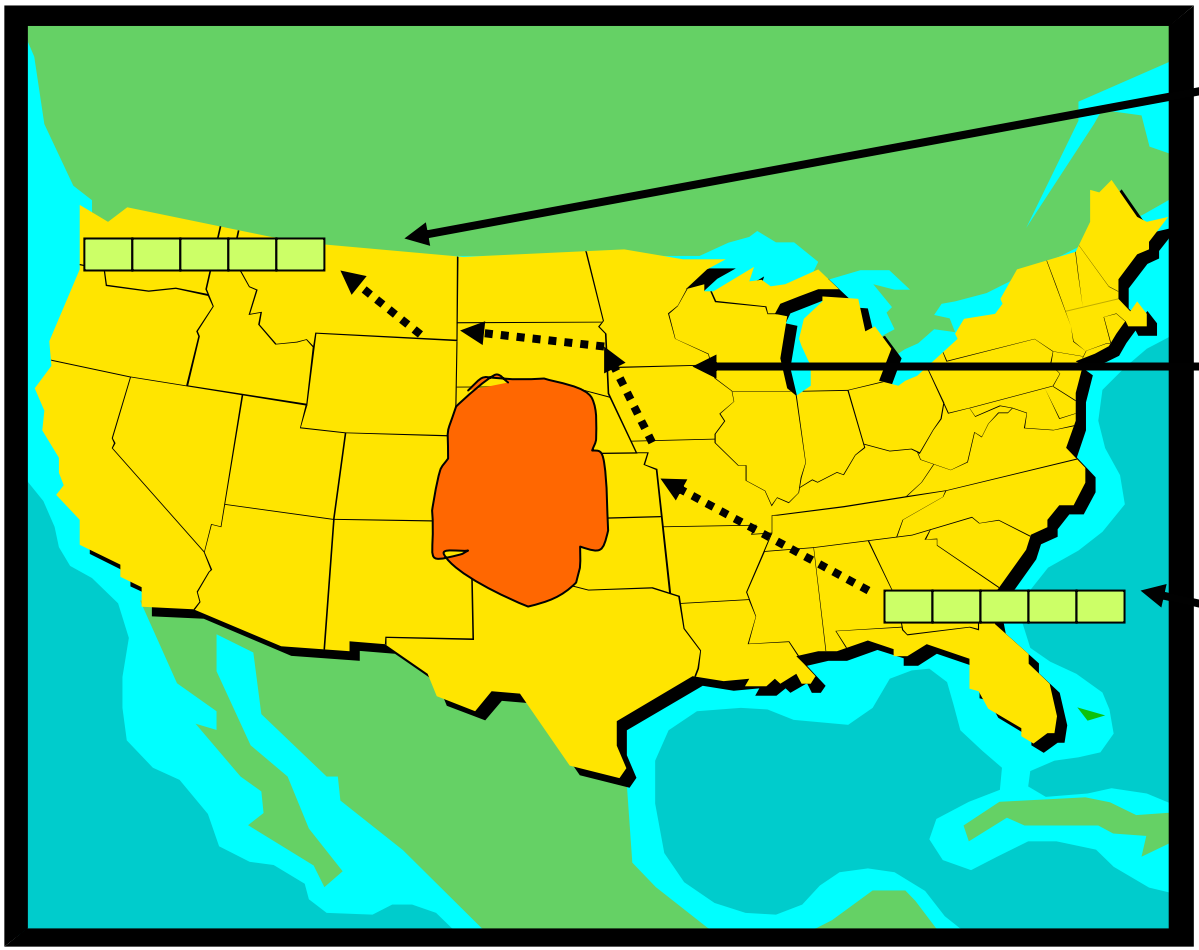


TFM in the Future

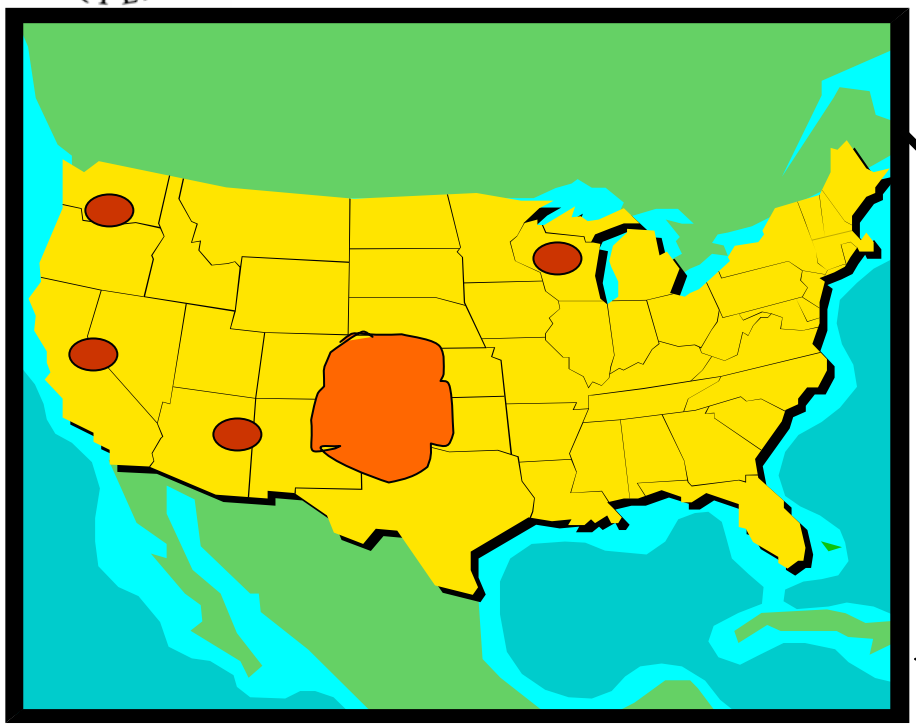
- Even if new technologies and procedures substantially enhance airspace capacity and safety, it is unlikely that the need to effectively manager traffic will go away.
- TFM problems are every bit as challenging as technology development problems.

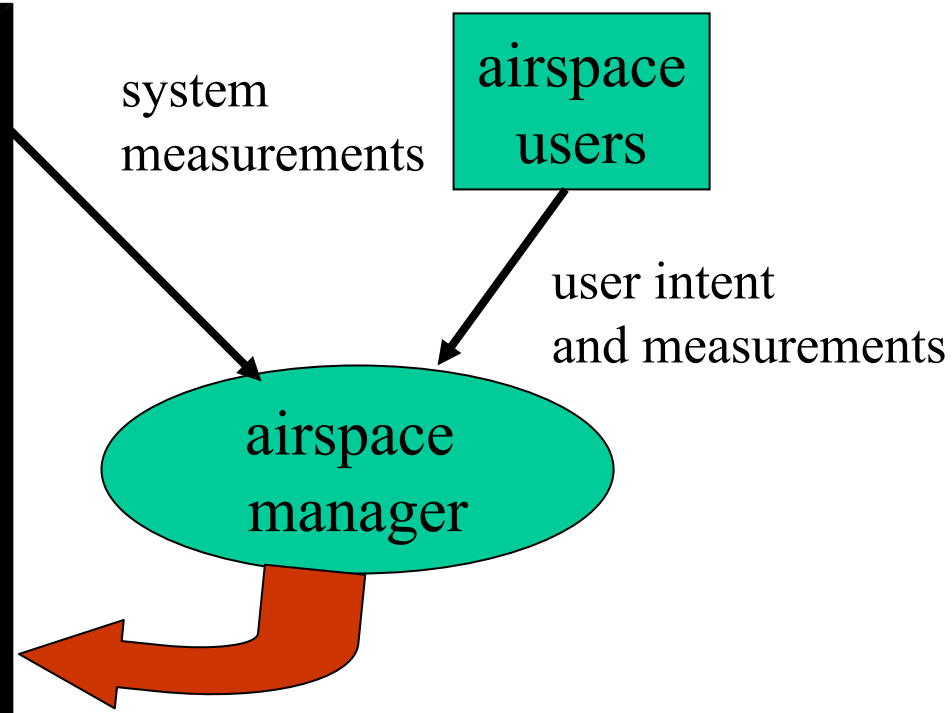
Competition for Scarce Resources

Even in 2010 – 2020 (free flight?) time frame there will be competition for scarce arrival, departure and enroute resources



Fundamental Problem: Prediction of Airspace Conditions





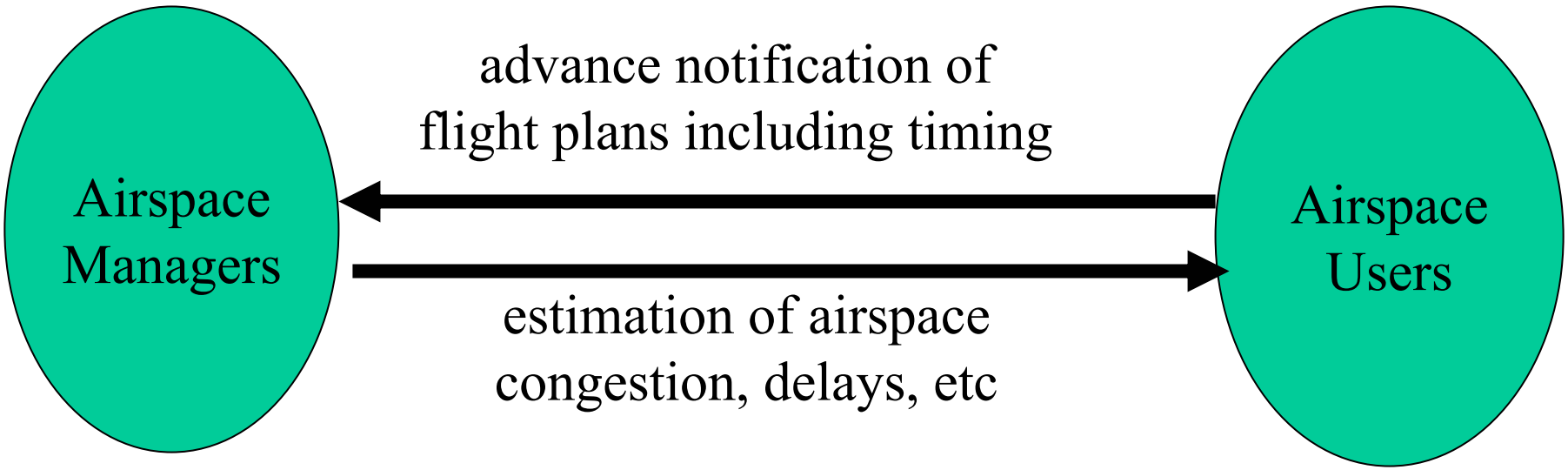
Congestion prediction; Delay estimation, etc.

Under any control scenario, it is essential that airspace managers be able to accurately estimate future conditions.

The prediction of future conditions represents a significant research challenge both under today's CNS paradigms and tomorrow's

Minimalist Airspace Manager

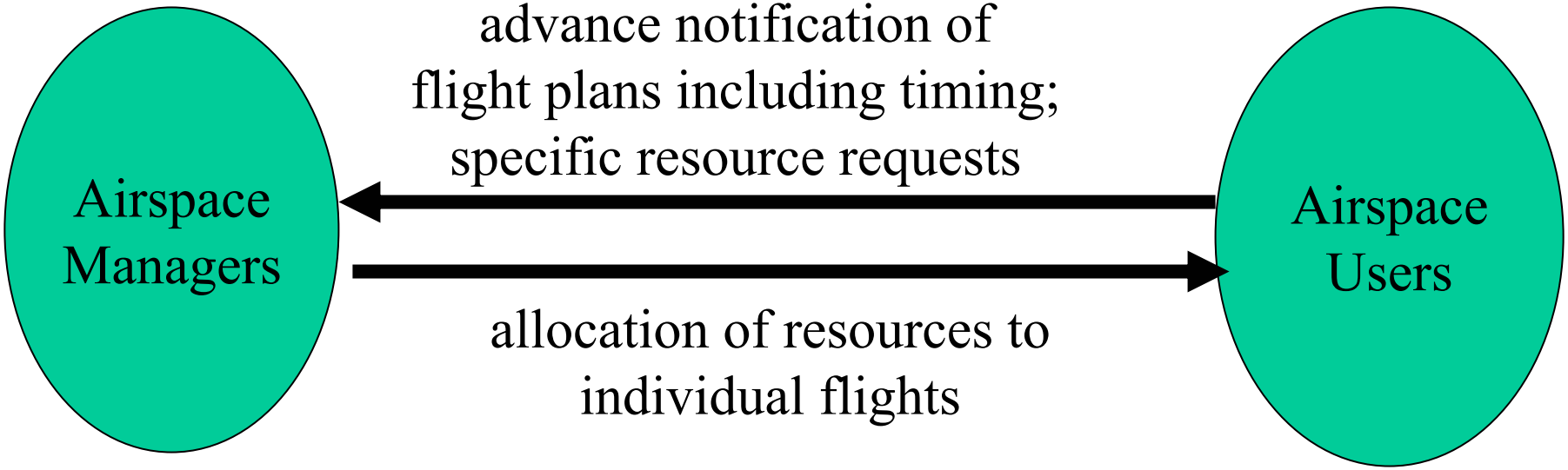
Users have total control over flight timing, flight plan, etc.



Is this system stable? Is it fair to all airspace users?
What are appropriate strategies for users? What new planning problems must they solve?
What controls are required on information exchange?

Central Controller Paradigm

Managers have total control over resource allocation and all airspace usage.



Can airspace managers efficiently solve large-scale airspace planning and control problem? Is the data availability and accuracy sufficient to support required planning? Will ultimate resource usage be fair? Will users be satisfied?

Collaborative Decision Making/Distributed Control

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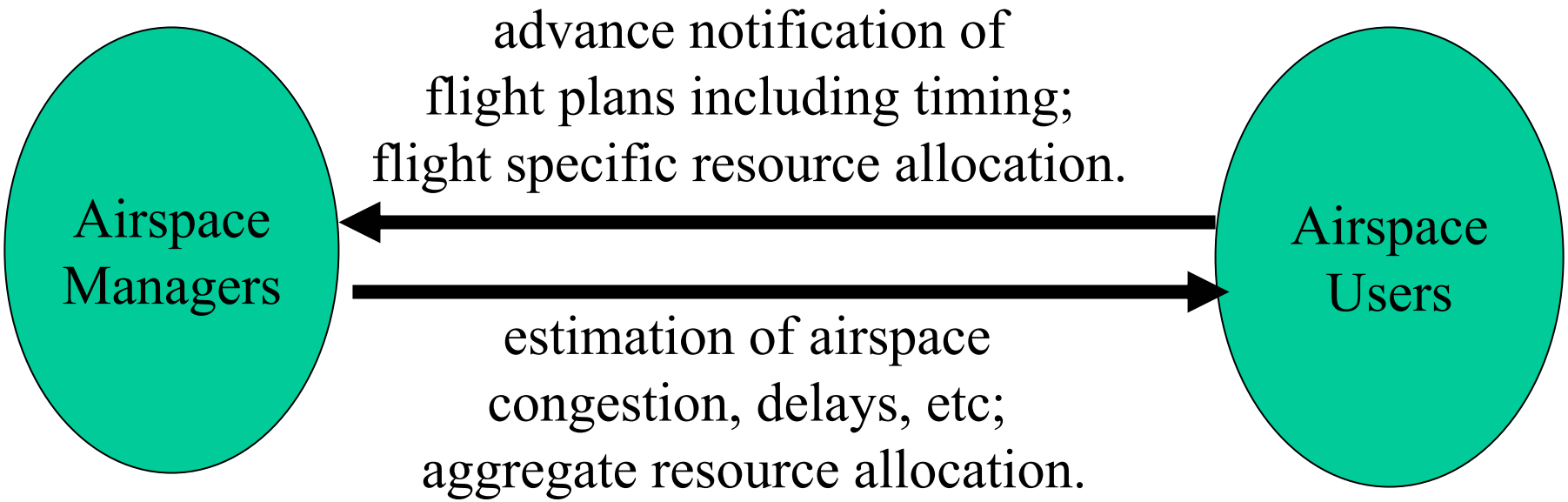
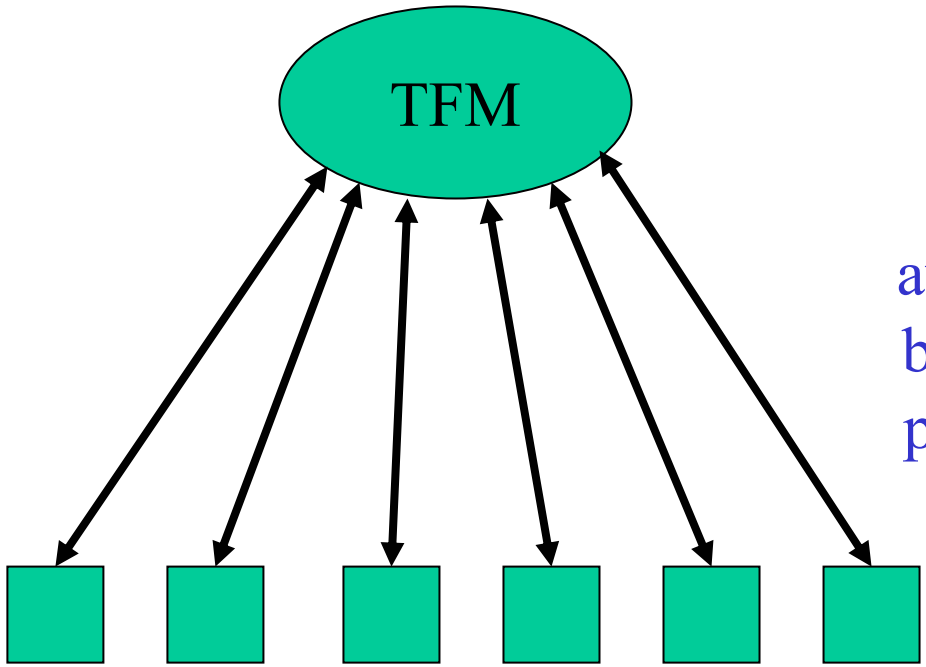
Managers oversee resource allocation; mediate resource exchange.
Users control resource use; allocate to specific flights.



Is this system stable? How are resources allocated? What resource exchange mechanisms should be used?
What are appropriate strategies for users? What new planning problems must they solve?

Real Time Resource Allocation
Option 1: Auction/Bidding Process



auction/
bidding
process

Airspace users

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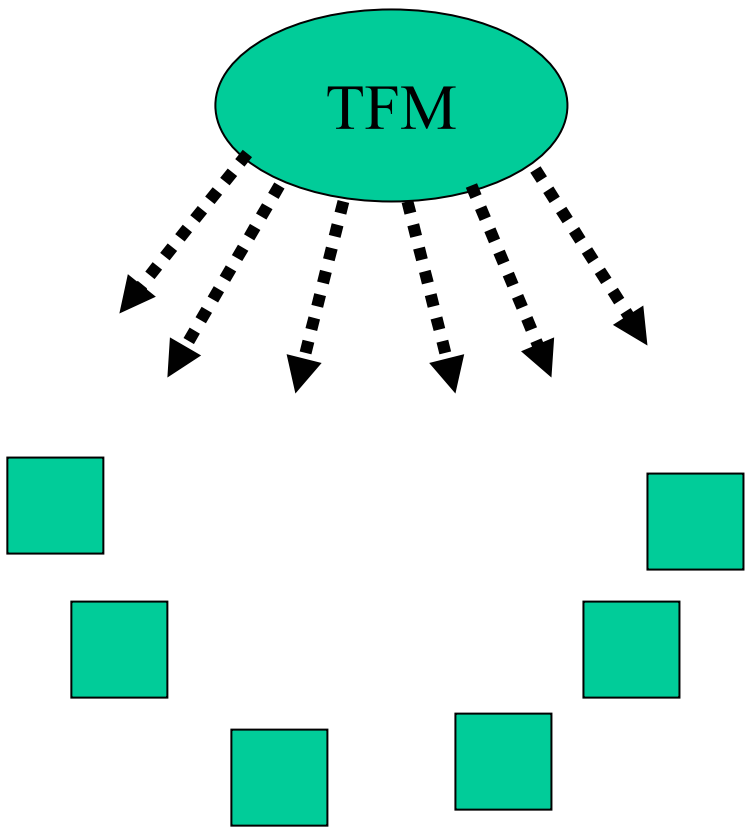
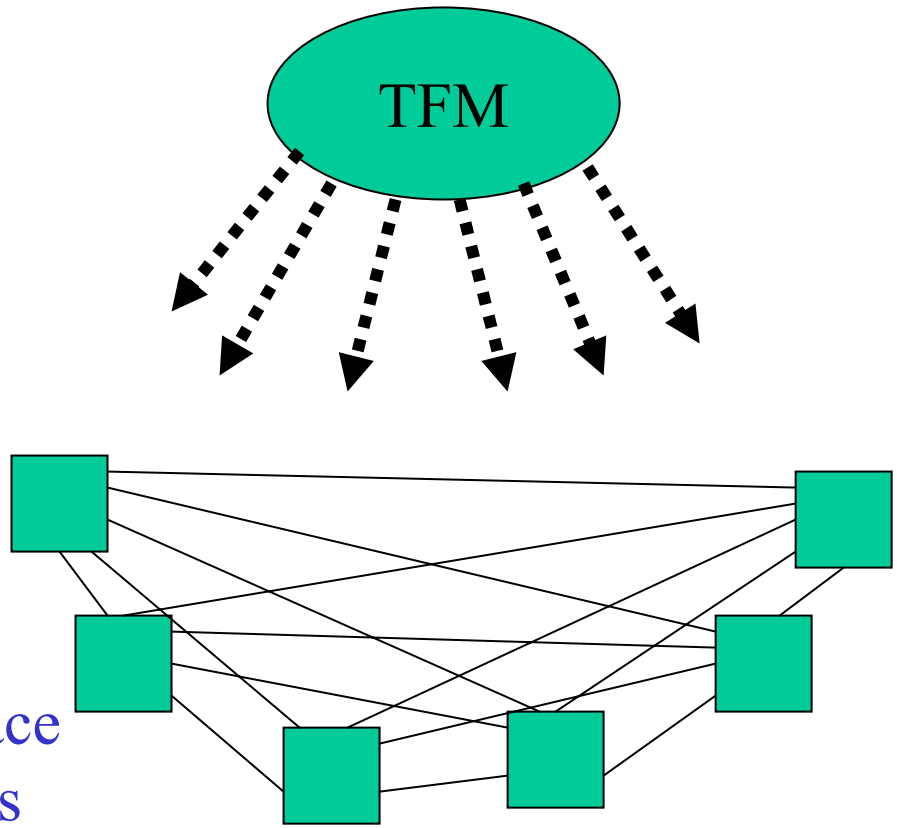
Real Time Resource Allocation
Option 2: Allocation -- Exchange

Step 1: "fair" allocation



Step 2: mediated exchange



airspace users

Philosophy of Alternate Approaches to Resource Allocation

Clearly airspace and airport resources are valuable commodities; their availability (and value) can vary widely from day to day depending capacity/demand conditions.

- Recognizing this, Option 1 directly auctions each day's resources.
- Philosophy of Option 2:
  - Users may compete (and pay) for static resource, e.g. 8 AM departure slot at LGA; 5PM arrival slot at DCA; 9 AM flight from BWI to SFO.
  - On a daily basis, possibly limited resources are allocated to users based on static resource owned.
  - Users can exchange (possibly for $$) resources owned.

Summary

- TFM problems won't go away – they are very challenging and becoming more challenging.
- Data collection, traffic monitoring, congestion prediction are key in any architecture.
- Need for distributed, coordinated control architectures and collaborative decision making; players include central and region flow managers, users and others.
- Economic principles of resource allocation and exchange must be applied to insure efficient resource utilization.